Monitoring and analyzing satellite signals
R&S®GSACSM communication system monitoring is a software solution for monitoring and analyzing satellite signals. It has a wide array of useful features for operators of satcom systems, regulatory authorities, and public safety and security authorities.

Operators of satcom systems are required to constantly monitor the status and quality of their satellite links. Regulatory authorities need access to the measurement results for the links in order to check for errors or tolerance violations that can impact the quality of other services. Public safety and security authorities have to access the relevant data for identification and intelligence purposes (Fig. 1). To support these applications, Rohde & Schwarz developed R&S®GSACSM communication system monitoring in cooperation with its INRADIOS subsidiary.

R&S®GSACSM enables worldwide access to RF sensors such as spectrum analyzers and power sensors as well as control of signal generators. Complete loopback or system tests can be remotely executed on large-scale installations, e.g. on antenna systems. The software works with the user’s existing Rohde & Schwarz equipment. Multiple users can simultaneously access the measurement data from the sensors. R&S®GSACSM combines analysis and digital demodulation methods on a graphical interface to allow consistent, user-friendly settings for a wide variety of instrument types.

R&S®GSACSM requests digitized signal fragments from the sensors, which it then demodulates and analyzes. The software automatically configures all of the relevant sensor parameters (center frequency, sampling rate, signal recording length, etc.). All of the demodulation and analysis functions are implemented in software and can be extended via updates.

### Key features of R&S®GSACSM
- Multichannel power measurement, history logging and alarm trapping
- Classic software-based spectrum analyzer functions
- R&S®GSACSM can be directly installed on Rohde & Schwarz test instruments such as the R&S®FSW signal and spectrum analyzer for reduced hardware expense
- Autonomous detection and identification of:
  - Satellite signals (DVB-S2, DVB-S1, etc.)
  - PCMA signals
  - TDMA signals
  - Carrier in carrier
  - DVB-CID signals
- Simultaneous access to multiple remote spectrum analyzers
- Offline analysis of recorded signal files
- Remote spectrum monitoring over narrowband links and long latency links

### Target group and application scenarios

<table>
<thead>
<tr>
<th>Target group</th>
<th>Application scenarios</th>
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<tbody>
<tr>
<td>Satellite operators</td>
<td>Continuous monitoring of satcom links, status monitoring and alarm trapping based on carrier parameters such as $E_b/N_0$, $C/N$, data rate, receive power, etc.</td>
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<tr>
<td>Regulatory authorities</td>
<td>Interference detection based on carrier-in-carrier analysis. Using CIC, for example, it is possible to look in or “under” a carrier in order to demodulate and classify potential interfering signals.</td>
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<tr>
<td>Public safety and security authorities</td>
<td>Identification of unknown satcom signals using the extensive carrier analysis functions provided by R&amp;S®GSACSM. Detection of modulation methods and error protection coding for intelligence purposes.</td>
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</table>
R&S®GSACSM modules

The software typically includes these modules:

- **R&S®GSACSM sensor:** Recording/digitization of signals from instruments connected to the R&S®GSACSM server via a network or TCP/IP connection, e.g.:
  - R&S®FSW, R&S®FPS, R&S®FSV signal and spectrum analyzers
  - R&S®FSC, R&S®FSG, R&S®FSL spectrum analyzers
  - R&S®TSME6 drive test scanner
  - R&S®NRQ6 power sensor
  - R&S®OSP open switch and control platform
  - R&S®ESMD wideband monitoring receiver
  - R&S®MSR200 dual satellite receiver

- **R&S®GSACSM server:** This software controls and manages user interaction with the sensors. It transfers or processes the measurement results, manages access rights for individual users, and controls multi-user access to the RF sensors. R&S®GSACSM server performs cyclically recurring measurements and saves the results (e.g. spectrum data, I/Q signal files, power values) in a database.

- **R&S®GSACSM user:** This graphical user interface plays the role of a classic multi-screen, multi-sensor desktop monitoring application. Fig. 2 shows the system’s different operating modes.

### Examples of standalone and client/server scenarios

1. **Standalone**
   - R&S®NRQ6 power sensor
   - R&S®GSACSM user
   - R&S®GSACSM server

2. **Distributed sensors, single user**
   - R&S®NRQ6 power sensor
   - R&S®GSACSM user
   - R&S®GSACSM server
   - R&S®FPS signal and spectrum analyzer
   - R&S®FSW signal and spectrum analyzer
   - R&S®TSME drive test scanner

3. **Distributed sensors, multiple users**
   - R&S®NRQ6 power sensor
   - R&S®GSACSM user
   - R&S®GSACSM server
   - Site 1
     - R&S®GSACSM user
     - R&S®GSACSM server
   - Site 2
     - R&S®GSACSM user
     - R&S®GSACSM server
   - Site 3
     - R&S®GSACSM user
     - R&S®GSACSM server

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**Fig. 2:** Possible R&S®GSACSM operating modes.
R&S®GSACSM server can also run directly on certain Rohde & Schwarz test instruments without a separate computer (e.g. on the R&S®FPS or R&S®FSW). This is beneficial for users who already own these instruments and want an easy way to extend them with R&S®GSACSM or who do not have space for extra hardware. Often there is no way to provide additional processing capacity for monitoring purposes, e.g. in mobile satcom terminals. Here too, installation of R&S®GSACSM on an existing Rohde & Schwarz instrument is a way to extend system functionality.

### Table: Manufacturer (SCPC) and Modem Designation

<table>
<thead>
<tr>
<th>Manufacturer (SCPC)</th>
<th>Modem designation</th>
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<tbody>
<tr>
<td>COMTECH</td>
<td>LDPC 2/3</td>
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<td></td>
<td>LDPC 3/4</td>
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<td>VersaFEC 0.642L</td>
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<td>VersaFEC 0.789L</td>
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<tr>
<td>IDirect</td>
<td>TPC 0.793 Infinity</td>
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<td>Radyne</td>
<td>TPC 3/4</td>
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<td></td>
<td>VSAT defacto</td>
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<tr>
<td>Various</td>
<td>TPC 7/8</td>
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### Table: Manufacturer (TDMA) and Modem Designation

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<tbody>
<tr>
<td>Viasat</td>
<td>LinkWay, LinkWayS2, SurfBeam, SkyLinx DDS</td>
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<tr>
<td>Nortel</td>
<td>DASA SKYWAN (IDU 200, 3000, 5000, 7000)</td>
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<tr>
<td>PolarSat</td>
<td>VSATPlus II</td>
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<td>VSATPlus 3</td>
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<td>SatLink</td>
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<tr>
<td>Gilat</td>
<td>SkyBlaster, FaraWay, SkyEdge</td>
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<td></td>
<td>SkyEdge II, DialAway, SkyStar VARIANT</td>
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<tr>
<td>Hughes</td>
<td>DIRECWAY (IPoS), PE5</td>
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<tr>
<td>Shiron</td>
<td>InterSKY</td>
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<tr>
<td>Comtech / Radyne</td>
<td>SkyWire</td>
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<tr>
<td>Various</td>
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<td>Various</td>
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<tr>
<td>NEC</td>
<td>NEXTAR48 (IC), NEXTAR4A (OC), NEXTAR Bandwidth On Demand, NEXTARV0</td>
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</table>

**Fig. 3:** SCPC and TDMA satellite signals that can be detected by R&S®GSACSM, and manufacturer-specific modem designations.

**Remote controlled spectrum and signal monitoring**

R&S®GSACSM accesses the distributed sensors via network or TCP/IP connections. The software not only supports monitoring of signals from a single instrument, it can also simultaneously operate a number of different RF sensors. Fig. 3 shows some of the single carrier per channel (SCPC) and TDMA satellite signals that can be detected.

**Fig. 4:** Users can define spectrum signal masks to ensure that every suspicious carrier is immediately identified. The R&S®GSACSM server can also run on test instruments such as the R&S®FSW signal and spectrum analyzer, i.e. a separate computer is not required.
Spectrogram to identify signal parts using color-coded waterfall charts
Systems using R&S®GSACSM can monitor the power spectral density of any spectrum analyzer input signal. This helps identify potential unwanted signal sources. The spectrogram function with 2D and 3D waterfall charts is very helpful in this regard (Fig. 5).

Spectrum density measurement identifies sporadic signal parts
The spectrum density measurement monitors time-varying and superimposed signals by continuously capturing and analyzing spectrums over time. Rare or superimposed events that cannot be detected using ordinary spectrum analyzer functions can be visualized in a spectrum density chart.

Fig. 5: The spectrogram function produces color-coded 2D and 3D waterfall charts that are useful for identifying signal parts.
Alarm trapping helps automatically identify suspicious signals
Alarm thresholds in R&S®GSACSM inform users when unwanted signals occur. Users can define spectrum signal masks to ensure that every suspicious carrier is immediately identified (Fig. 4). Besides identifying suspicious carriers, it is also possible to monitor the frequency and power stability of wanted carriers. The system collects statistics and can send alerts via email when errors occur.

Identification of underlying signal sources via carrier-in-carrier detection
Under-carrier detection and signal identification
With its R&S®GSA1400/20 CiC separator, R&S®GSACSM detects and identifies paired carrier multiple access (PCMA) signals (Fig. 6).

Identification of suspicious interferers using under-carrier detection
The R&S®GSA1400/10 CiC separator’s under-carrier detection feature detects and identifies unwanted asymmetric signals underneath a wanted signal. The demodulated signals and all necessary signal parameters are clearly presented, making it easy to correctly interpret the measurement results.

Satellite transponder monitoring
R&S®GSACSM can scan user-specific satcom carriers (e.g. DVB-S, DVB-S2, DVB-RCS, etc.) and evaluate the signal quality as well as the modulation and coding schemes, making it possible to quickly detect anomalies or impairments on individual carriers and notify the user (Fig. 7). Typical impairments that are automatically detected include:
- Carrier missing or signal not recognizable
- Highly fluctuating carrier center frequency
- Carrier bandwidth or baud rate outside standard limits
- Reduced carrier-to-noise (C/N) ratio

In modern satcom systems, lots of signal interference can occur between satellite signals such as DVB-S2. To be able to quickly identify and eliminate such interference, the DVB consortium has developed a carrier identification standard (DVB-CID) for satellite transmissions that allows the host carrier to be identified. R&S®GSACSM provides a software-based DVB-CID demodulation function to automatically detect and

Fig. 6: The R&S®GSA1400/10 CiC separator detects hidden signals and separates overlapping components.
Fig. 7: R&S®GSACSM automatically identifies and demodulates all signals in a user-specific spectrum.

Fig. 8: Via carrier ID (CID), DVB-S signals can be unambiguously assigned to their operator.
identify the CID of unknown or interfering signals. The CID-specific global unique ID, the uplink GPS coordinates and the operator’s telephone number (if available) are extracted. The global unique ID allows customers to precisely identify their satellite signal. Fig. 8 shows continuous spectrum scanning to detect and demodulate the CID signal until all CID-specific parameters have been successfully identified.

**Station and channel measurements with R&S®GSACSM and pilot feeding**

In addition to ordinary signal monitoring and analysis, the received signal power is an important criterion for sat operators. It is also mandatory for sat operators to monitor spectral power density masks for their carriers in order to prevent interference to adjacent satellite systems. R&S®GSACSM can be used together with signal generators from Rohde & Schwarz to perform extensive measurements. The ground station is retrofitted with a so-called pilot path in addition to the actual receive path. The pilot path provides a pilot signal that can be used to measure the frequency-dependent gain of the entire receive path ("station gain") from the LNB to the L-band interface (Fig. 9). Based on the measured values, additional carrier parameters can be calculated:

- Spectral signal power density at receive antenna
- EIRP or power density at satellite
- EIRP of carrier at satellite antenna (downlink)
- Signal attenuation due to free-space propagation, rain and atmospheric attenuation using known beacon signals

If the satellite beacon power is known, the signal level or gain can be determined at any point on the transmission path (from satellite to modem) for each component (e.g. antenna – satellite, path, LNB, etc. including influence of optical converters). Based on regular measurements, it is possible to detect aging effects and take appropriate countermeasures – all during live operation.

Dr. Steffen Bittner; Dr. Marco Krondorf

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**Measurement of frequency-dependent gain**

![Diagram of measurement setup](image)

Fig. 9: Using the pilot path, the frequency-dependent gain can be determined for the entire receive path.